4.4. Quantifying impacts of cassava-based hillside land uses on system resilience to environmental disturbance

Objective

To understand the potential impacts of cassava-based land use systems on resilience of hillside agro-ecosystems to perturbations

Methods

Data from field trial research conducted at the Santander de Quilichao Research Station, Cauca Department of southwest Colombia were used in this research. The long-term cropping systems included:

- Bare fallow continuously clean tilled, no fertilizer, and no crop;
- Cassava with rototiller treatment, 4 t ha^{-1} chicken manure;
- Cassava in monoculture with rototiller treatment, no fertilizer;
- Cassava in minimum tillage, no rototiller, 300 kg ha^{-1} mineral fertilizer;
- Cassava with rototiller treatment, 8 t ha^{-1} chicken manure;
- Cassava as a single crop with vetiver grass as a double-row life barrier occupying 12.5% of the plot area with rototiller treatment, 4 t ha^{-1} chicken manure;
- Cassava intercropped with *Chamaechrista rotundifolia* with rototiller treatment, 300 kg ha^{-1} mineral fertilizer;
- Cassava in rotation with *Bracchiaria decumbens* and *Centrosema macrocarpum*, 300 kg ha^{-1} mineral fertilizer; and
- Cassava with rototiller treatment, 300 kg ha^{-1} mineral fertilizer.

Soil structure was indirectly quantified by measuring the resistance of the soil to penetration using a pocket penetrometer (Daiki Soil and Moisture Sensors, Model DIK-5560) on a weekly basis during the period from January 2000 until December 2001.

The experiment plots were designed as completely randomized blocks with three repetitions. Six measurement points were established on each plot, two at each end and two in the middle part of the plot. Four readings were taken at each measurement point and their mean noted. Weekly standard deviations about the mean of the 18 individual data (i.e., six readings in three reps) were calculated for each cropping system, and considered as an indicator for spatial variation of soil penetration resistance in each cropping system.

Results

Soil penetration resistance within the investigated cropping systems was on the average higher in 2000 than in 2001, and corresponded to the distribution of cumulative annual rainfall between the two years. While the absolute values decreased markedly from 2000 to 2001, the decrease of the range between lowest and highest penetration resistance was much smaller, indicating a systematic decrease across all cropping systems.

Intuitively, it is expected that higher rainfalls will cause the soil's resistance against penetration to decline. However, data revealed no linear relation between rainfall and soil penetration resistance. But data suggested that higher rainfalls would increase spatial variation of a soil's resistance to penetration.

Cassava minimum tillage has the highest weekly standard deviation values for both years. While cassava intensive tillage has the lowest weekly standard deviation values in 2000, it is second lowest in 2001 to bare fallow. Remarkable is the magnitude by which standard deviation values in cassava minimum tillage are higher than those in the other cropping systems. Cassava minimum tillage has also, in both years, the widest range of weekly standard deviation. Lowest ranges are found in cassava intensive tillage (2000), and bare fallow (2001). One-way analyses of variance confirmed that weekly standard deviation in cassava minimum tillage was significantly different ($P < 0.001$) from those of all other cropping systems in both examined years. When cassava minimum tillage was not included, the analysis of variance (ANOVA) revealed no further statistically significant differences between weekly standard deviations for the remaining cropping systems in 2000. When cassava minimum tillage was omitted from the variance analysis of 2001 statistically significant differences between most of the other cropping systems were exposed.

The partitioned mean squares from an ANOVA, which used cropping systems and weekly dates of measurements as variables, were studied to investigate the influence of precipitation on the spatial variation of penetration resistance. Partial mean squares are an indicator for the variance that is accounted for by the variables included in the ANOVA. In 2000, the partial mean squares for cropping systems were 2.3 larger than the variance accounted for by the measurements dates. In 2001, however, the year with much lower annual precipitation, the cropping system accounted for 7.5 times more variance than the measurements dates. Furthermore, when cassava minimum tillage was excluded from the ANOVA, partial mean squares indicated that, in 2000, measurement dates accounted for 3.6 times more variation than cropping systems. In 2001, the year with low precipitation, however, cropping systems still accounted for about 1.5 times more variation than did the measurement dates. These results indicate that low precipitation acts as filter, amplifying differences in spatial variation between the various cassava-based cropping systems.

The general trends documented suggest that higher precipitation will increase both the soil's resistance to penetration and the spatial variation of the penetration resistance. This trend is not consistent with general understanding that relates higher precipitation with lower resistance of soils to penetration. To further investigate this trend, we grouped the rainfall data into precipitation classes combining weeks with low, medium, high, and very high weekly precipitation. In both years, resistance against penetration and spatial variation of resistance is generally decreasing from weeks with low to weeks with medium amounts of precipitation in most cropping systems. However, resistance against penetration and its spatial variation is again increasing in both years from weeks with medium to weeks with high rainfall. The exception is cassava minimum tillage, for which, in 2001, resistance and its spatial variation decrease consistently from weeks with low rainfall to weeks with high rainfall. Hence, increases in resistance and its spatial variation are predominantly caused by very high-rainfall events. Furthermore, correlation between the amount of weekly cumulative rainfall and resistance, and its spatial variation, is for both years consistently negative, indicated by low (2000) and moderate (2001) coefficients of correlation. It is likely that the impact of the aforementioned events with very high rainfalls prevented stronger negative correlations.

Output

Increased, but environmentally sustainable productivity of hillside cropping systems through improved land use management.

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